Thermal energy storage in solar energy systems: editorial

Luisa F. Cabeza

GREiA Research Group, INSPIRES Research Centre, Universitat de Lleida, Pere de Cabrera s/n, 25001 Lleida, Spain

One of the main drawbacks of solar energy is the mismatch between supply and demand in time, temperature, power or location. Thermal energy storage (TES) is the technology that can overcome this drawback. This special issue has the purpose of presenting different options for the use of thermal energy storage in solar energy systems and applications.

TES technologies include sensible, latent and sorption and chemical reactions (also known as thermochemical energy storage). Considering latent storage, Crespo et al., 2019 review the potential of this technology for solar process heat applications for industry. The potential industries that could apply this solar technology are identified. Moreover, the materials for latent TES (phase change materials, PCM) with more potential are listed, together with a summary of the performance of the system from an experimental and modelling point of view. Another study carried out by Badenhorst 2019 is the consideration of the use of carbon in PCM to increase their thermal conductivity with a very wide view, including synthetic and natural graphite, graphitic fibres, graphitic foams, expanded graphite, graphite nano-platelets, graphene, carbon nanotubes, and amorphous carbons. The review states that particulate additives have lower performance than matrix materials.

Considering sorption storage, Palomba and Frazzica, 2019 review the recent advancements in the sorption technology for solar applications. The review includes an analysis of innovative sorbent materials (liquid absorption, physical adsorption, chemical reactions in pure salts, and composite sorbents) and summarizes prototypes recently developed for each sorbent class.

Focussing in applications, buildings have the potential of high use of solar energy to achieve the ambitious target of net-zero energy buildings. Piselli et al., 2019 present a case study of how PCM can enhance roofs thermal performance by varying the solar reflectance and, therefore, reducing the building energy demand. And they do this for different climates. Another case study is developed by Panno et al. 2019, where a solar assisted seasonal borehole TES for two non-residential buildings is presented. Results show the energy and economic performance of the system, highlighting the advantage of the use of the TES system.

Facci et al., 2019 study the transition from natural gas to electricity-based heating for residential buildings considering the use of PV electricity production combined with heat pumps and TES.

Results give basis for considering larger penetration of PCM plants when TES is used. With a wider perspective, Akbari et al. 2019 review all possibilities of energy storage for PV both at building level and at power plant level, considering both electrical and thermal energy storage.

One step forward is reaching zero-energy communities. Hachem-Vermette et al., 2019 present a solar mixed-use community (a community combining residential, commercial, and institutional buildings) using solar thermal energy combined with a borehole TES. Results show that implementing this system combined with PV systems allow producing around 70% of the total energy consumption with high-energy performance.

Concentrating solar power (CSP) plants acknowledge TES as the key for their deployment, since this is the key to achieve dispatchability in electricity, an advantage versus other renewable energy production. Today, commercial CSP plants used double tanks indirect systems with molten salts (60 wt.% $NaNO_3$ – 40 wt.% KNO_3) as TES system. Prieto et al., 2019 addresses one of the issues in these commercial plants, the decomposition of the molten salts from the point of view of the effect of its main impurity when nitrates from mining origin is used, magnesium. Results of the papers demonstrate that this impurity, $MgNO_3$, is the main source of nitrate oxides emissions, but only during the commissioning of the plant since those emissions happen in the first melting of the salts. The paper also proposes a way to avoid such pollution. Future CSP plants require new TES systems able to work at higher temperatures. Almendros-Ibáñez et al. 2019 review a promising technology, the use of solid particles, with special focus to their technology for the implementation, packed beds and fluidized beds. Other than summarizing both technologies, the review also highlights the need to find new materials for this application of solar energy.

To measure the economic sustainability of any system, life cycle costing is a widely used methodology. Ximenes Naves et al. 2019 show that this methodology can be successfully used in CSP plants and in PV plants, including thermal energy storage (TES) and electricity energy storage (EES). The review also shows that this methodology can be used to assess TES included in smaller solar systems, for example in buildings.

Acknowledgements

This work was partially funded by the Ministerio de Ciencia, Innovación y Universidades de España (RTI2018-093849-B-C31). The author would like to thank the Catalan Government for the quality accreditation given to her research group GREiA (2017 SGR 1537). GREiA is a certified agent TECNIO in the category of technology developers from the Government of Catalonia. This work is partially supported by ICREA under the ICREA Academia programme.

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